$\Upsilon(11020)$

$$I^{G}(J^{PC}) = 0^{-}(1^{-})$$

$\Upsilon(11020)$ MASS

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT			
11000 ± 4 OUR AVERAGE							
11000.0^{+}_{-} $\begin{array}{ccc} 4.0 + & 1.0 \\ 4.5 - & 1.3 \end{array}$	¹ MIZUK	19	BELL	$e^+e^-\to$	γ (1S, 2S, 3S) $\pi^+\pi^-$		
$10999.0 {}^{+}_{-} {}^{7.3}_{-8.0} {}^{+16.9}_{-1.0}$	² MIZUK	16	BELL	$e^+e^- \to$	$h_b(1P, 2P)\pi^+\pi^-$		
• • • We do not use th	e following data for	avera	ges, fits,	limits, etc.	• • •		
$11003.0 \pm \ 1.1 ^{+}_{-} \ 1.0$	3,4 SANTEL	16	BELL	$e^+e^-\to$	hadrons		
10987.5^{+}_{-} $\begin{array}{ccc} 6.4 + & 9.1 \\ -2.5 - & 2.3 \end{array}$	^{5,6} SANTEL	16	BELL	$e^+e^- \rightarrow$	Υ (1S, 2S, 3S) $\pi^+\pi^-$		
10996 ± 2	⁷ AUBERT	09E	BABR	$e^{+}e^{-}\rightarrow$	hadrons		
$11019 ~\pm~ 5 ~\pm~ 7$	BESSON			$e^+e^- \rightarrow$			
11020 ± 30	LOVELOCK	85	CUSB	$e^+e^- \rightarrow$	hadrons		

¹ From a simultaneous fit to the $\Upsilon(nS)\pi^+\pi^-$, n=1, 2, 3, cross sections at 28 energy points within $\sqrt{s}=10.6$ –11.05 GeV, including the initial-state radiation at $\Upsilon(10860)$.

² From a simultaneous fit to the $h_b(\text{nP})\pi^+\pi^-$, n=1, 2 cross sections at 22 energy points within $\sqrt{s}=10.77-11.02$ GeV to a pair of interfering Breit-Wigner amplitudes modified by phase space factors, with eight resonance parameters (a mass and width for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single relative phase, a single relative amplitude, and two overall normalization factors, one for each n). The systematic error estimate is dominated by possible interference with a small nonresonant continuum amplitude.

³ From a fit to the total hadronic cross sections measured at 60 energy points within \sqrt{s} = 10.82–11.05 GeV to a pair of interfering Breit-Wigner amplitudes and two floating continuum amplitudes with $1/\sqrt{s}$ dependence, one coherent with the resonances and one incoherent, with six resonance parameters (a mass, width, and an amplitude for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, one relative phase, and one decoherence coefficient).

⁴ Not including uncertain and potentially large systematic errors due to assumed continuum amplitude $1/\sqrt{s}$ dependence and related interference contributions.

⁵ From a simultaneous fit to the $\Upsilon({\rm nS})\pi^+\pi^-$, $n=1,\,2,\,3$, cross sections at 25energy points within $\sqrt{s}=10.6$ –11.05 GeV to a pair of interfering Breit-Wigner amplitudesmodified by phase space factors, with fourteen resonance parameters (a mass, width, and threeamplitudes for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single universal relativephase, and three decoherence coefficients, one for each n). Continuum contributions weremeasured (and therefore fixed) to be zero.

⁶ Superseded by MIZUK 19.

⁷ In a model where a flat non-resonant $b\overline{b}$ -continuum is incoherently added to a second flat component interfering with two Breit-Wigner resonances. Systematic uncertainties not estimated.

Υ (11020) WIDTH

VALUE (MeV)	DOCUMENT	ID	TECN	COMMENT
24 + 8 OUR AVERAG	GE			
23.8^{+}_{-} $\begin{array}{ccc} 8.0 + & 0.7 \\ 6.8 - & 1.8 \end{array}$	$^{ m 1}$ MIZUK	19	BELL	$e^+e^- ightarrow ~ \gamma({ m nS})\pi^+\pi^-$
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	² MIZUK	16	BELL	$e^+e^- \rightarrow h_b(1P, 2P)\pi^+\pi^-$
HTTP://PDG.LBL.G	OV	Page 1	L	Created: 6/1/2020 08:32

• • • We do not use the following data for averages, fits, limits, etc. • • •

¹ From a simultaneous fit to the $\Upsilon({\rm nS})\pi^+\pi^-$, $n=1,\,2,\,3$, cross sections at 28 energy points within $\sqrt{s}=10.6$ –11.05 GeV, including the initial-state radiation at $\Upsilon(10860)$.

³ From a fit to the total hadronic cross sections measured at 60 energy points within \sqrt{s} = 10.82–11.05 GeV to a pair of interfering Breit-Wigner amplitudes and two floating continuum amplitudes with $1/\sqrt{s}$ dependence, one coherent with the resonances and one incoherent, with six resonance parameters (a mass, width, and an amplitude for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, one relative phase, and one decoherence coefficient).

⁴ Not including uncertain and potentially large systematic errors due to assumed continuum amplitude $1/\sqrt{s}$ dependence and related interference contributions.

⁵ From a simultaneous fit to the $\Upsilon({\rm nS})\pi^+\pi^-$, $n{=}1$, 2, 3, cross sections at 25energy points within $\sqrt{s}=10.6{-}11.05$ GeV to a pair of interfering Breit-Wigner amplitudesmodified by phase space factors, with fourteen resonance parameters (a mass, width, and threeamplitudes for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single universal relativephase, and three decoherence coefficients, one for each n). Continuum contributions weremeasured (and therefore fixed) to be zero.

⁶ Superseded by MIZUK 19.

 7 In a model where a flat non-resonant $b\overline{b}$ -continuum is incoherently added to a second flat component interfering with two Breit-Wigner resonances. Systematic uncertainties not estimated.

au(11020) DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	e^+e^-	$(5.4^{+1.9}_{-2.1}) \times 10^{-6}$
Γ ₃	$egin{array}{l} \varUpsilon(1S) \pi^+ \pi^- \ \varUpsilon(2S) \pi^+ \pi^- \ \varUpsilon(3S) \pi^+ \pi^- \end{array}$	
Γ ₆	$egin{array}{l} \chi_{bJ}(1P)\pi^+\pi^-\pi^0 \ \chi_{b1}(1P)\pi^+\pi^-\pi^0 \ \chi_{b2}(1P)\pi^+\pi^-\pi^0 \end{array}$	$(9 \begin{array}{c} +9 \\ -8 \end{array}) \times 10^{-3}$ seen seen

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² From a simultaneous fit to the $h_b(\text{nP})\pi^+\pi^-$, n=1, 2 cross sections at 22 energy points within $\sqrt{s}=10.77-11.02$ GeV to a pair of interfering Breit-Wigner amplitudes modified by phase space factors, with eight resonance parameters (a mass and width for each of $\Upsilon(10860)$ and $\Upsilon(11020)$, a single relative phase, a single relative amplitude, and two overall normalization factors, one for each n). The systematic error estimate is dominated by possible interference with a small nonresonant continuum amplitude.

au(11020) PARTIAL WIDTHS

•	•				
$\Gamma(e^+e^-)$					Г ₁
VALUE (keV)	DOCUMENT ID		TECN	COMMENT	
0.130 ± 0.030 OUR AVERAGE	DECCON	0.5	CLEO	$e^+e^- \rightarrow$	
$0.095 \pm 0.03 \pm 0.035$ 0.156 ± 0.040	BESSON LOVELOCK	85 85		$e^+e^- \rightarrow e^+e^- \rightarrow$	
J.130 ± 0.040	LOVELOCK	00	COSB	e · e →	Hadrons
$\Gammaig(e^+e^-ig) imes \Gammaig(\varUpsilon(1S)\pi^+ au)$ VALUE (eV)	τ ⁻)/Γ _{total}		TECN	COMMENT	$\Gamma_1\Gamma_2/\Gamma$
● ● We do not use the follow		es, fits			
0.46 ± 0.08	^{1,2} MIZUK	19	BELL	$e^+e^- ightarrow$	$\gamma_{(nS)\pi^+\pi^-}$
1 From a simultaneous fit to points within $\sqrt{s}=10.6$ – 11^2 Reported as the range 0.38–within a model composed as	1.05 GeV, including -0.54 eV obtained fr	the in om mi	itial-state ultiple so	e radiation a lutions of ar	it $\Upsilon(10860)$.
$\Gamma(e^+e^-) \times \Gamma(\Upsilon(2S)\pi^+\tau)$	$(\tau^-)/\Gamma_{total}$				$\Gamma_1\Gamma_3/\Gamma$
VALUE (eV)	DOCUMENT ID			COMMENT	
• • We do not use the follow					
	^{1,2} MIZUK	19	BELL	$e^+e^- \rightarrow$	$\Upsilon(nS)\pi^+\pi^-$
1 From a simultaneous fit to points within $\sqrt{s}=10.6$ – 11	1.05 GeV, including	the in	itial-state	e radiation a	it $\Upsilon(10860)$.
¹ From a simultaneous fit to points within $\sqrt{s}=10.6$ –11 ² Reported as the range 0.13–within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau)$	L.05 GeV, including -1.16 eV obtained fr s a sum of Breit-Wi τ [—])/Γ _{total}	the in om mi	itial-state ultiple so unctions.	e radiation a lutions of ar	at $\Upsilon(10860)$. In amplitude fit
1 From a simultaneous fit to points within $\sqrt{s}=10.6$ – 11^{2} Reported as the range 0.13–within a model composed as $\Gamma(e^{+}e^{-}) \times \Gamma(\Upsilon(3S)\pi^{+}\eta)$ WALUE (eV)	1.05 GeV, including -1.16 eV obtained fr s a sum of Breit-Wi τ ⁻)/Γ _{total} <u>DOCUMENT ID</u>	the in om mi gner f	itial-state ultiple so unctions. <u>TECN</u>	e radiation a lutions of ar COMMENT	at $\Upsilon(10860)$. In amplitude fit
¹ From a simultaneous fit to points within $\sqrt{s} = 10.6$ –11 ² Reported as the range 0.13–within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau_{VALUE\ (eV)})$ • • • We do not use the follow	1.05 GeV, including 1.16 eV obtained fr s a sum of Breit-Wi T-)/F _{total} DOCUMENT ID ing data for average	the in om mi gner f	itial-state ultiple so unctions. <u>TECN</u> , limits, e	e radiation a lutions of ar COMMENT	at $\Upsilon(10860)$. The amplitude fit $\Gamma_1\Gamma_4/\Gamma_1$
¹ From a simultaneous fit to points within $\sqrt{s} = 10.6$ –11 ² Reported as the range 0.13–within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau_{VALUE\ (eV)})$ • • • We do not use the follow	1.05 GeV, including restaurant of Breit-Wing a sum of Breit-Wing restaurant of Breit-Wing data for average 1.2 MIZUK the $\Upsilon(\text{nS})\pi^+\pi^-$, 1.05 GeV, including restaurant of 1.4 eV obtained fr	the in om migner fees, fits 19 $n=1$ the in om migner $n=1$	itial-state ultiple so unctions. TECN , limits, o BELL , 2, 3, co itial-state ultiple so	e radiation a lutions of an elutions of an elution	of $\Upsilon(10860)$. The second structure of $\Upsilon(10860)$. The second structure of $\Upsilon(10860)$. The second structure of $\Upsilon(10860)$.
¹ From a simultaneous fit to points within $\sqrt{s} = 10.6$ –11 ² Reported as the range 0.13–within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau_{VALUE}) \times \bullet \text{We do not use the follow } 0.33\pm0.16$ ¹ From a simultaneous fit to points within $\sqrt{s} = 10.6$ –11 ² Reported as the range 0.17–within a model composed as	1.05 GeV, including 1.16 eV obtained from a sum of Breit-Wing 1.16 eV obtained from a sum of Breit-Wing data for average 1.2 MIZUK the $\Upsilon(\text{nS})\pi^+\pi^-$, 1.05 GeV, including 1.49 eV obtained from a sum of Breit-Wing 1.16 eV obtained from a	the in om migner fees, fits 19 $n=1$ the in om migner $n=1$	itial-state ultiple so unctions. TECN , limits, o BELL , 2, 3, co itial-state ultiple so	e radiation a lutions of an elutions of an elution	at $\Upsilon(10860)$. The property of $\Upsilon(10860)$ is amplitude find $\Gamma_1\Gamma_4/\Gamma_4$ and $\Gamma_1\Gamma_4/\Gamma_4$ and $\Gamma_1\Gamma_4/\Gamma_4$ and $\Gamma_1\Gamma_4/\Gamma_4$ and $\Gamma_1\Gamma_4/\Gamma_4/\Gamma_4$ and $\Gamma_1\Gamma_4/\Gamma_4/\Gamma_4$ and $\Gamma_1\Gamma_4/\Gamma_4/\Gamma_4/\Gamma_4/\Gamma_4/\Gamma_4/\Gamma_4/\Gamma_4/\Gamma_4/\Gamma_4/$
1 From a simultaneous fit to points within $\sqrt{s}=10.6$ – 11 Reported as the range 0.13–within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau_{VALUE}) \times \Psi(eV) \times \Psi$	1.05 GeV, including 1.16 eV obtained from a sum of Breit-Wing 1.16 eV obtained from a sum of Breit-Wing data for average 1.2 MIZUK the $\Upsilon(\text{nS})\pi^+\pi^-$, 1.05 GeV, including 1.49 eV obtained from a sum of Breit-Wing 1.16 eV obtained from a	the in om migner fees, fits $n=1$ the in om migner f	itial-state ultiple so unctions. TECN , limits, o BELL , 2, 3, cr itial-state ultiple so unctions.	e radiation a functions of an electric etc. • • • $e^+e^- \rightarrow$ ross sections a functions of an electric eradiation and electric eradiation and electric eradiation and electric eradiations of an electric eradiation and electric eradiation electric eradiati	of $\Upsilon(10860)$. The amplitude fit $\Gamma_1\Gamma_4/\Gamma$ of $\Gamma_1\Gamma_4/\Gamma$ of $\Gamma_1\Gamma_4/\Gamma$ of at 28 energy of $\Gamma_1\Gamma_4/\Gamma$ of amplitude fit $\Gamma_1\Gamma_4/\Gamma$
1 From a simultaneous fit to points within $\sqrt{s}=10.6$ – 11^2 Reported as the range 0.13 –within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau) \times \Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau) \times \Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau) \times \Gamma(e^+e^-) \times \Gamma(\pi(3S)\pi^+\tau) \times $	1.05 GeV, including 1.16 eV obtained fr s a sum of Breit-Wint τ^-)/ Γ_{total} DOCUMENT ID Ting data for average 1,2 MIZUK the $\Upsilon(nS)\pi^+\pi^-$, 1.05 GeV, including 1.49 eV obtained fr s a sum of Breit-Wint τ is a sum of Breit-Wint τ including 1.49 eV obtained from τ is a sum of Breit-Wint τ including 1.49 eV obtained from τ including 1.40 eV	es, fits 19 n = 1 the in om mi gner f	itial-state ultiple so unctions. TECN , limits, of BELL , 2, 3, contial-state ultiple so unctions.	e radiation a functions of an electric etc. • • • $e^+e^- \rightarrow$ ross sections a functions of an electric eradiation and electric eradiation and electric eradiation and electric eradiations of an electric eradiation and electric eradiation electric eradiati	of $\Upsilon(10860)$. The amplitude fit $\Gamma_1\Gamma_4/\Gamma$ of $\Gamma_1\Gamma_4/\Gamma$
¹ From a simultaneous fit to points within $\sqrt{s} = 10.6-11$ ² Reported as the range 0.13-within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau_{VALUE(eV)}) \times \Psi(T(3S)\pi^+\tau_{VALUE(eV)}) \times \Psi(T(3S)\pi^+\tau_{VALUE(eV)}) \times \Psi(T(3S)\pi^+\tau_{VALUE(eV)}) \times \Psi(T(3S)\pi^+\tau_{VALUE(eV)}) \times \Psi(T(3S)\pi^+\tau_{VALUE(eV)}) \times \Psi(T(3S)\pi^+\tau_{VALUE(eV)}) \times \Psi(T(3S)\pi^+\tau_{VALUE(units10^{-3})}) \times$	1.05 GeV, including 1.16 eV obtained fr s a sum of Breit-Wing τ^-)/ Γ_{total} $\frac{DOCUMENT\ ID}{DOCUMENT\ ID}$ ring data for average 1,2 MIZUK the $\Upsilon(nS)\pi^+\pi^-$, 1.05 GeV, including 1.049 eV obtained fr s a sum of Breit-Wing 1.05 GeV, including 1.049 eV obtained fr s a sum of Breit-Wing 1.05 GeV, including 1.05 GeV, inclu	the in om migner fes, fits 19 n = 1 the in om migner f	itial-state ultiple so unctions. TECN , limits, of BELL , 2, 3, critial-state ultiple so unctions. TECN BELL TECN BELL	e radiation a functions of an electric set $e^+e^- \rightarrow e^+e^- \rightarrow e^-e^- \rightarrow e^+e^- \rightarrow e^-e^- \rightarrow e^-e^-e^- \rightarrow e^-e^- \rightarrow e^-e^-e^- \rightarrow e^-e^- \rightarrow e^-e^-$	of $\Upsilon(10860)$. The amplitude fit $\Gamma_1\Gamma_4/\Gamma$ of $\Gamma_1\Gamma_4/\Gamma$
¹ From a simultaneous fit to points within $\sqrt{s} = 10.6-11$ ² Reported as the range 0.13-within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau)$ VALUE (eV) • • • We do not use the follow 0.33 ± 0.16 ¹ From a simultaneous fit to points within $\sqrt{s} = 10.6-11$ ² Reported as the range 0.17-within a model composed as $\Gamma(\chi_{bJ}(1P)\pi^+\pi^-\pi^0)/\Gamma_{total}$ VALUE (units 10^{-3}) 8.7 ± 4.3 $^{+7.6}_{-6.6}$ $\Gamma(\chi_{b1}(1P)\pi^+\pi^-\pi^0)/\Gamma_{total}$ VALUE	1.05 GeV, including 1.16 eV obtained fr s a sum of Breit-Wint τ^-)/ Γ_{total} DOCUMENT ID ring data for average 1,2 MIZUK the $\Upsilon(nS)\pi^+\pi^-$, 1.05 GeV, including 1.49 eV obtained fr s a sum of Breit-Wint 1.50 GeV, including	es, fits 19 n = 1 the in om mi gner f	itial-state ultiple so unctions. TECN , limits, of BELL , 2, 3, contitial-state ultiple so unctions. TECN BELL TECN BELL	e radiation a functions of an electric set $e^+e^- \rightarrow e^+e^- \rightarrow e^-e^- \rightarrow e^+e^- \rightarrow e^-e^- \rightarrow e^-e^-e^- \rightarrow e^-e^- \rightarrow e^-e^-e^- \rightarrow e^-e^- \rightarrow e^-e^-$	at $\Upsilon(10860)$. The amplitude find the amplitude fi
points within $\sqrt{s}=10.6-11$ ² Reported as the range 0.13- within a model composed as $\Gamma(e^+e^-) \times \Gamma(\Upsilon(3S)\pi^+\tau)$ $VALUE \text{ (eV)}$ • • • We do not use the follow 0.33 ± 0.16 ¹ From a simultaneous fit to points within $\sqrt{s}=10.6-11$ ² Reported as the range 0.17-	1.05 GeV, including 1.16 eV obtained fr s a sum of Breit-Wing τ^-)/ Γ_{total} $\frac{DOCUMENT\ ID}{DOCUMENT\ ID}$ ring data for average 1,2 MIZUK the $\Upsilon(nS)\pi^+\pi^-$, 1.05 GeV, including 1.05 GeV, including 1.049 eV obtained fr s a sum of Breit-Wing 1.05 GeV, including 1.05 GeV, includin	the in om migner fes, fits 19 n = 1 the in om migner f	itial-state ultiple so unctions. TECN , limits, of BELL , 2, 3, critial-state ultiple so unctions. TECN BELL TECN BELL TECN BELL	e radiation a fultions of an elutions of an elutions of an elutions $e^+e^- \rightarrow e^+e^- \rightarrow e^-e^- \rightarrow e^-e^$	at $\Upsilon(10860)$. The amplitude fit $\Gamma_1\Gamma_4/\Gamma$ and $\Gamma_1\Gamma_4/\Gamma$ and $\Gamma_1\Gamma_4/\Gamma$ and $\Gamma_1\Gamma_4/\Gamma$ and $\Gamma_1\Gamma_4/\Gamma$ and $\Gamma_1\Gamma_4/\Gamma$ hadrons Γ_6/Γ

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$\Gamma(\chi_{b2}(1P)\pi^{+}\pi^{-}\pi^{0})/\Gamma(\chi_{b1})$	$(1P)\pi^{+}\pi^{-}\pi^{0}$)		Γ_7/Γ_6
<u>VALUE</u>	DOCUMENT ID)	TECN	COMMENT
0.4±0.2	YIN	18	BELL	$e^+e^- o$ hadrons

au(11020) REFERENCES

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LOVELOCK 85 PRL 54 377 D.M.J. Lovelock et al. (CUSB Colla	ıb.)

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